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PATENT APPLICATION



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UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark
Address: ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20530

#2

U.S. APPLICATION NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
08/817,445	HEINZ	W 8436.43USWO

INTERNATIONAL APPLICATION NO.

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5611

PCT/NZ95/00106

I.A. FILING DATE	PRIORITY DATE
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10/16/95 11/04/94

DATE MAILED: 06/16/97

**NOTIFICATION OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C. 371
AND 37 CFR 1.494 OR 1.495**

1. The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as ☐ a Designated Office (37 CFR 1.494), ☒ an Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is **ACCEPTED** for national patentability examination in the United States Patent and Trademark Office.

2. The United States Application Number assigned to the application is shown above and the relevant dates are:

30 APR 1997

35 U.S.C. 102(e) DATE

30 APR 1997

DATE OF RECEIPT OF
35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371(C) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363). Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

3. ☒ A request for immediate examination under 35 U.S.C. 371(f) was received on **30 APR 1997** and the application will be examined in turn.

4. The following items have been received:

- ☒ U.S. Basic National Fee.
- ☒ Copy of the international application in:
 - ☐ a non-English language.
 - ☒ English.
- ☒ Translation of the international application into English.
- ☒ Oath or Declaration of inventors(s) for DO/EO/US.
- ☒ Copy of Article 19 amendments. ☐ Translation of Article 19 amendments into English.

The Article 19 amendments ☐ have ☐ have not been entered.
- ☒ The International Preliminary Examination Report in English and its Annexes, if any.
- ☒ Translation of Annexes to the International Preliminary Examination Report into English.

The Annexes ☒ have ☐ have not been entered.
- ☒ Preliminary amendment(s) filed **30 APR 1997** and _____
- ☐ Information Disclosure Statement(s) filed _____ and _____
- ☐ Assignment document.
- ☐ Power of Attorney and/or Change of Address.
- ☐ Substitute specification filed _____
- ☒ Verified Statement Claiming Small Entity Status.
- ☐ Priority Document.
- ☒ Copy of the International Search Report ☐ and copies of the references cited therein.
- ☐ Other:

Applicant is reminded that any communication to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above. (37 CFR 1.5)

Valerie R. Radwell
Patent Specialist
Telephone: (703) 305-3656

POT/NZ9C/00106



IN THE PATENT OFFICE.
NEW ZEALAND

PAT II
08/817445 #3

REC'D	22 DEC 1995
WIPO	PCT

In the matter of the Patents Act 1953
and the Regulations thereunder;

AND

In the matter of an application for
Letters Patent, numbered 264864 in
the name of

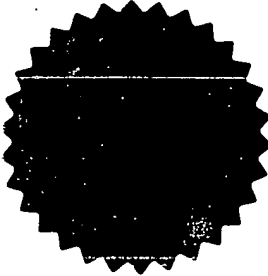
DELTEC NEW ZEALAND LIMITED.

PRIORITY DOCUMENT

Certificate

I NATALIE JOAN GRAY Assistant Commissioner of Patents for New Zealand,
Hereby Certify that annexed is a true copy of the Provisional Specification
(including drawings) as filed on 4 November 1994, with an application for
Letters Patent, numbered 264864 made by DELTEC NEW ZEALAND LIMITED.

AS WITNESS MY HAND THIS 30th day of NOVEMBER 1995.



Natalie Gray

264864

Patents Form No. 4

Our Ref: DT/AS203610

Patents Act 1953

PROVISIONAL SPECIFICATION

A MECHANICAL DRIVE SYSTEM

We, DELTEC NEW ZEALAND LIMITED, a New Zealand company, of 84 Main Road, Tawa, Wellington New Zealand do hereby declare this invention to be described in the following statement:

-1-

PT0462394



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The present invention relates to a mechanical drive system for use in the adjustment of one or more RF circuit elements. More particularly, although not exclusively the present invention relates to an adjustment drive for use in an antenna which incorporate one or more phase shifters.

In order to produce downtilt in the beam produced by an antenna array (for example a panel antenna) it is possible to either mechanically tilt the panel antenna or electrically steer the beam radiated from the panel antenna according to techniques known in the art.

Panel antenna such as those with which the present application is concerned, are often located on the sides of buildings or similar structures. Mechanical tilting of the antenna away from the side of the building increases the susceptibility of the installation to wind induced vibration and can impact on the visual environment in situations where significant amounts of downtilt are required.

In order to avoid the above difficulties, electrical beam steering can be effected by introducing phase delays into the signal input into radiating elements or groups of radiating elements in an antenna array. Such techniques are described in New Zealand Patent Specification No. 235010.

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Various phase delay techniques are known, including inserting variable length delay lines into the network feeding to the radiating element or elements, or using PIN diodes to vary the phase of a signal transmitted through the feeder network.

A further means for varying the phase of two signals is described in PCT/NZ94/00107 whose disclosure is incorporated herein by reference. This specification describes a mechanically operated variable differential phase shifter incorporating one input and two outputs.

For the present purposes it is sufficient to note that phase shifters such as those described in PCT/NZ94/00107 are adjusted mechanically by sliding an external sleeve along the body of the phase shifter which alters the relative phase of the signals at the phase shifter outputs.

A typical panel antenna will incorporate one or more phase shifters and the present particular embodiment includes three phase shifters. A signal is input to the primary phase shifter which splits the signal, each phase shifted signal is then input into a secondary phase shifter whose outputs feeds at least one radiating element. In this manner a progressive phase shift can be achieved across the entire radiating element array thus providing for a means of electrically adjusting the downtilt of the radiated beam. Other phase distributions are possible

depending on the application and directivity of the radiated beam.

While the steering action is discussed in the context of downtilt of the radiated beam, it is to be understood that the present detailed description is not limited to such a direction. Upward tilt may be produced as desired.

Another particular feature of the variable differential phase shifters is that they provide a continuous phase adjustment, in contrast with the more conventional stepped phase adjustments normally found in PIN diode or variable length delay line phase shifters.

In a panel antenna of the type presently under consideration, it is desirable to adjust the entire phase shifter array simultaneously so that a desired degree of beam tilt may be set by the adjustment of a single mechanical setting means. The mechanical drive which performs such an adjustment must result in reproducible downtilt angles and be able to be adapted to provide for a number of different phase shifter array configurations.

It is an object of the present invention to provide a mechanical drive system for use in adjusting mechanical phase shifters which mitigates the abovementioned difficulties, provides a solution to the design requirements of the antennas or antenna

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arrays described above, or which at least provides the public with a useful choice.

According to one aspect of the invention there is provided a mechanical radio frequency circuit element adjustment device for adjusting one or more radio frequency circuit elements where each element incorporates one input, one or more outputs and is adjustable by moving a first part of the circuit element with respect to a second part of the circuit element, and the first part of the circuit element incorporates the input,

the mechanical radio frequency circuit element adjustment device comprises:

- a moveable carriage adapted to hold one or more primary RF circuit element;

- one or more control rods adapted to:

 - electrically connect each output of the primary circuit element to a corresponding input of a fixed secondary circuit element, where the fixed secondary circuit elements are in fixed relation to one another;
 - and,

 - provide for the movement of the carriage to be transmitted to the first parts of the secondary circuit elements;

- an adjustment means adapted to:

 - provide a first displacement of the carriage with respect to the secondary circuit elements; and
 - adapted to provide for a second displacement of the

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first part of the primary circuit element with respect to the second part of the primary circuit element, wherein the first and second displacements are in a fixed ratio.

The radio frequency circuit elements may be mechanical phase shifters.

The control rods may be rigid tubes adapted to contain a coaxial transmission cable.

The control rods may be substantially linear.

The adjustment means may comprise:

- a compound gear which is fixed relative to the secondary RF circuit elements and comprises first and second rotatable gears fixed coaxially together;

- a first gear rack fixed to the moveable first part of the primary RF circuit element and adapted to engage the first gear;

- a second gear rack fixed to the carriage and adapted to engage the second gear; and

- a third gear adapted to engage the first gear, so that upon rotation of the third gear the second gear produces the first displacement of the carriage and the co-rotating first gear produces the second displacement in the first part of the primary RF circuit element.

The third gear may be adapted to be manually rotated.

The third gear may be adapted to be electrically rotated.

The dimensions of the first and second gears may be adapted so that the ratio of the first and second displacements are in a fixed ratio of 1:2.

There may be one primary RF circuit element which is secured to the carriage and two secondary RF circuit elements.

The outputs of the secondary RF circuit elements may feed one or more radiating elements.

The radiating elements may be dipoles.

The adjustment means may incorporate a locking means.

The locking means may comprise a locking gear rack secured to the carriage and adapted to releasably engage the third gear where the third gear may be displaced axially so as to engage the locking gear rack.

An embodiment of the invention is now described, by way of example only, with reference to the drawings in which:

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Figure 1: illustrates a schematic view of a phase shifter drive mechanism mounted on the rear face of a panel antenna.

Figure 2: illustrates a primary phase shifter incorporating a gear rack.

Figure 3: illustrates an exploded view of the adjustment assembly incorporated into the carriage.

Referring to figure 1 the rear face of a panel antenna 21 is shown. A primary phase shifter 13 is secured to carriage 10 where the outputs 15 and 16 of the primary phase shifter are in the form of rigid linear push rods extending parallel to the slideable axis of the primary phase shifter. The control rods 15 and 16 feed the input of secondary phase shifters 11 and 12 respectively. The moveable first part of the primary phase shifter is indicated by 14 and is in the form of a sliding sleeve which additionally incorporates the input which is fed by the signal conductor 22.

Secondary phase shifters 11 and 12 operate similarly, where sleeves 23 and 22 are adjusted simultaneously by the movement of the carriage 10 transmitted by the push rods 15 and 16.

Each output of the secondary phase shifters feeds a T-junction where each branch feeds a radiating element.

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Upon rotation of the first gear 19 the moveable part of the primary phase shifter 14 is displaced linearly parallel to the axis of the primary phase shifter. The second gear (not shown) is fixed to the first gear 19 and engages with a gear rack secured to the carriage 10. Upon rotation of the first gear 19 the carriage 10 is displaced linearly in a direction parallel to the axis of the phase shifter. It can be seen that because of the different gear ratio between a first and second gear the relative displacements between the carriage 10 and the sleeve 14 may be fixed. The first and second gears are fixed relative to the back of the panel antenna.

Because the primary phase shifter 13 is secured to the carriage 10, upon rotation of the second gear and the resulting lateral displacement of the carriage 10, the push rods simultaneously move the first part 22 and 23 of each of the secondary phase shifters. These sleeves incorporate the secondary phase shifter input.

The main signal input cable 22 is flexible to allow for the displacement of the sleeve 14 which incorporates the input to the primary phase shifter.

First gear 19 is rotated by means of the third gear (not shown) which in a preferred embodiment is a knob marked with beam angles. The adjustment means may be locked by moving the knob and hence the third gear axially which partially disengages it

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from the first gear and engages it with a locking gear rack which is secured to the adjustment means 18.

This is to avoid situations where the beam angle may wander resulting from the vertical orientation of the panel antenna combined with slippage of the sleeves 23, 22 and 14 on the primary and secondary phase shifters.

It is also envisaged that the rotation of the third gear (not shown) may be effected by a lever means, stepper motors or other techniques which are within the purview of one skilled in the art.

The linear movement of the carriage 10 and push rods 15 and 16 may be used to provide an indication of beam tilt whereby a "thermometer" style indicator may be calibrated in terms of carriage displacement versus beam tilt.

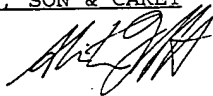
It is also envisaged that the third gear may be replaced with a worm drive in which the gear system is adapted to engage with a worm cog and drive rod extending parallel to the axis of the phase shifter.

The particular embodiment described feeds an array of eight dipoles. However, it is envisaged that adaptations of the present invention may be constructed for an array with a greater or lesser number of radiating elements.

It is to be understood that the scope of the invention is not limited to the described embodiments and therefore numerous variations and modifications may be made to these embodiments without departing from the scope of the invention.

DELTEC NEW ZEALAND LIMITED

By their Attorneys
BALDWIN, SON & CAREY



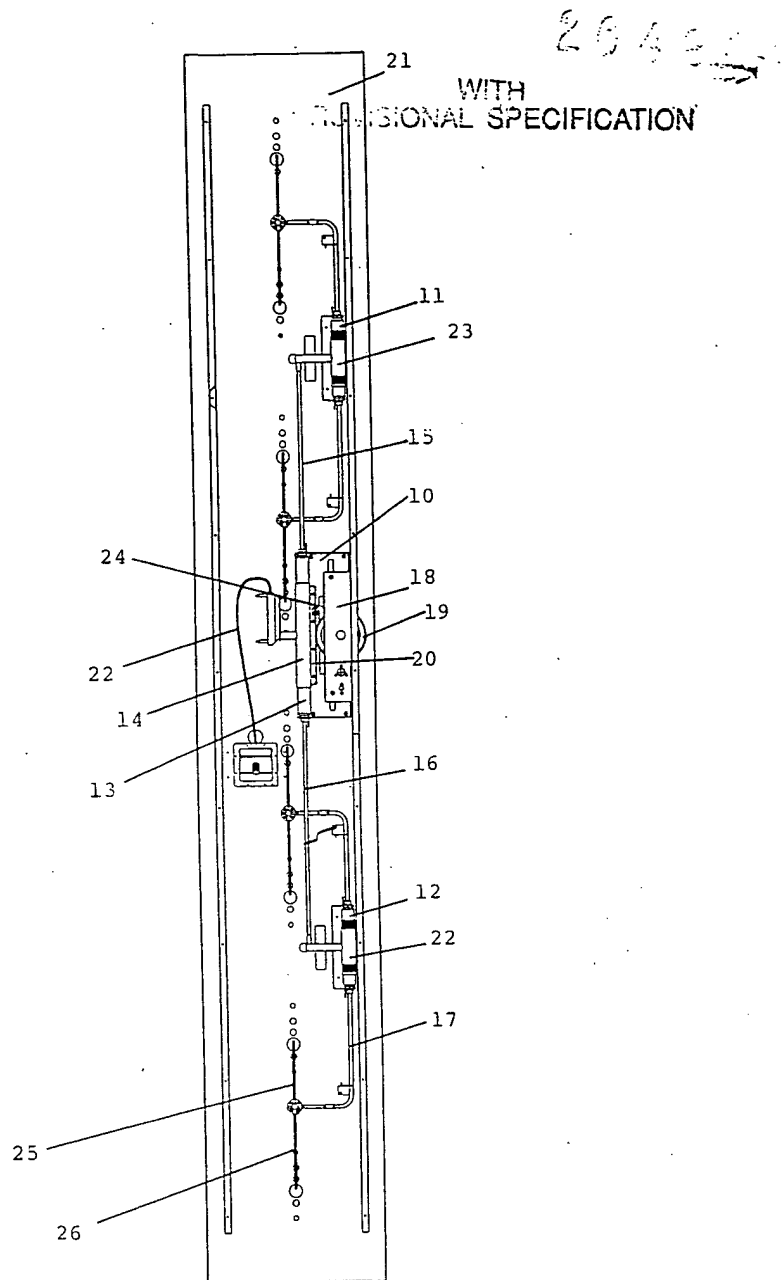


Figure 1

DELTEC NEW ZEALAND LIMITED
By their Attorneys
BALDWIN, SON & CAREY

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WITH
PROVISIONAL SPECIFICATION

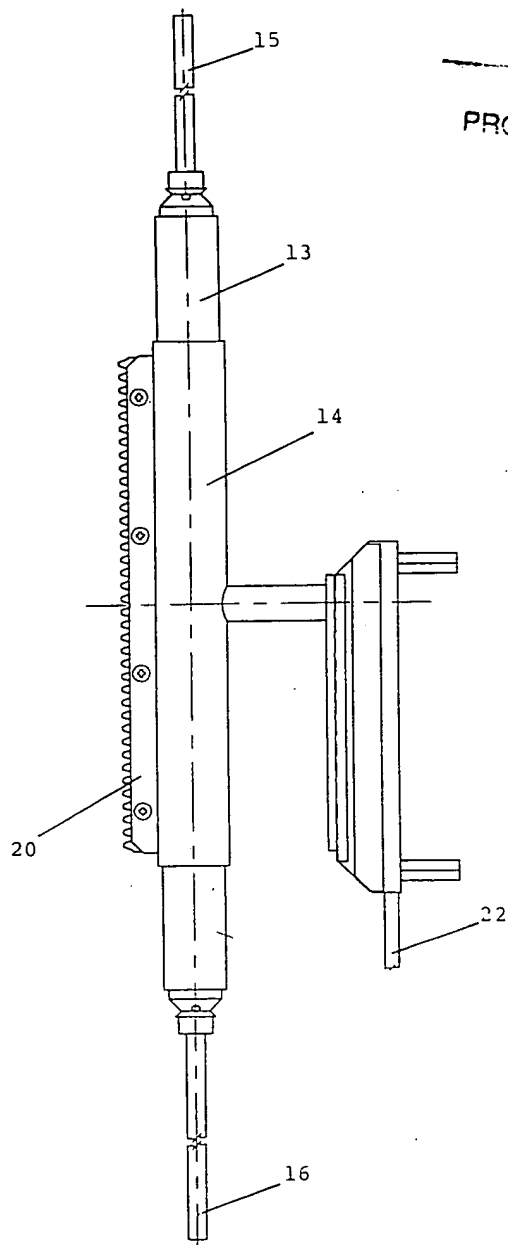


Figure 2

DELTEC NEW ZEALAND LIMITED
By their Attorneys
BALDWIN, SON & CAREY

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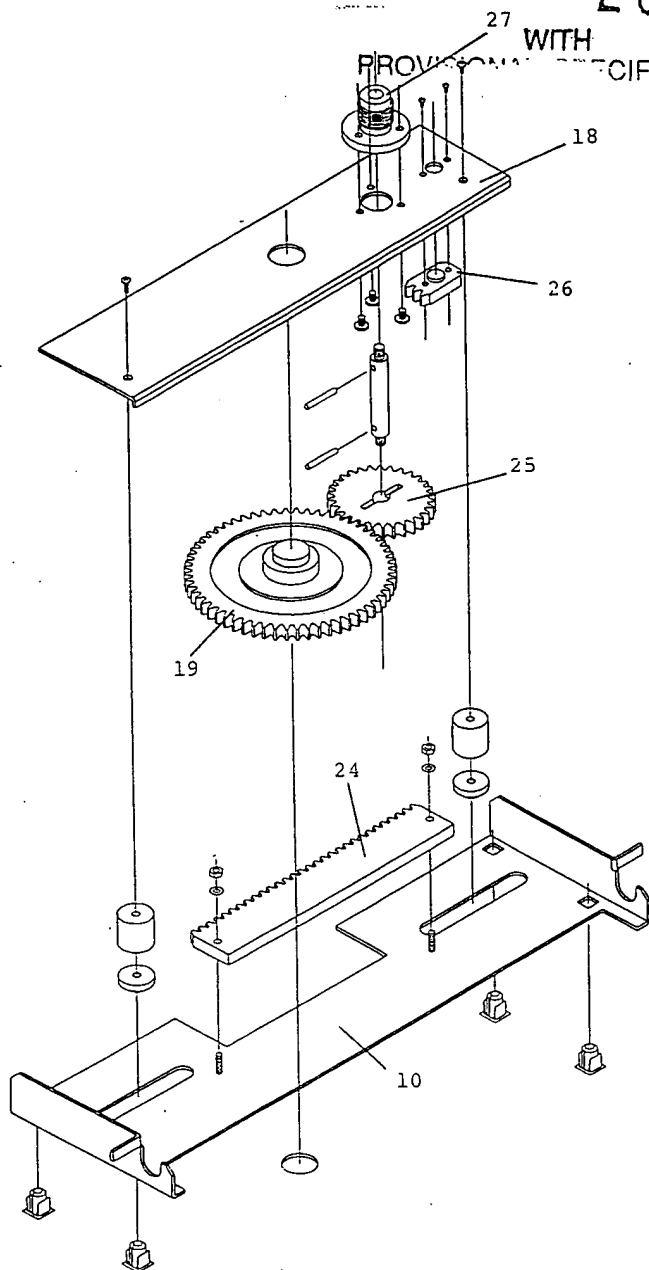


Figure 3

DELTEC NEW ZEALAND LIMITED
By their Attorneys
BALDWIN, SON & CAREY

RT/NZ94/00106



PAT 11

IN THE PATENT OFFICE.
NEW ZEALAND

REC'D	22 DEC 1995
WIPO	PCT

In the matter of the Patents Act 1953
and the Regulations thereunder;

AND

In the matter of an application for
Letters Patent, numbered 272778 in
the name of DELTEC NEW ZEALAND
LIMITED.

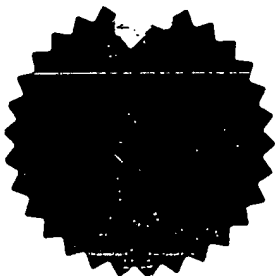
PRIORITY DOCUMENT

Certificate

I NATALIE JOAN GRAY Assistant Commissioner of Patents for New Zealand,
Hereby Certify that annexed is a true copy of the Provisional Specification
(including drawings) as filed on 15 August 1995, with an application for Letters
Patent, numbered 272778 made by DELTEC NEW ZEALAND LIMITED.

AS WITNESS MY HAND THIS 4th day of DECEMBER 1995.

Natalie Gray



272778

Patents Form No. 4

Our Ref: JT204646

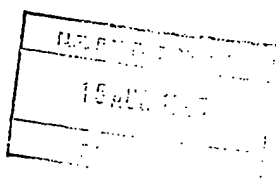
Patents Act 1953

PROVISIONAL SPECIFICATION

AN ANTENNA CONTROL SYSTEM

We, DELTEC NEW ZEALAND LIMITED, a New Zealand company, of
84 Main Road, Tawa, Wellington New Zealand do hereby
declare this invention to be described in the following
statement:

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The present invention relates to a mechanical drive system for use in the adjustment of one or more RF circuit element. More particularly, although not exclusively the present invention relates to drive system for use in an antenna which incorporates one or more phase shifter.

In order to produce downtilt in the beam produced by an antenna array (for example a panel antenna) it is possible to either mechanically tilt the panel antenna or electrically steer the beam radiated from the panel antenna according to techniques known in the art.

Panel antennas, such as those to which the present application is concerned, are often located on the sides of buildings or similar structures. Mechanical tilting of the antenna away from the side of the building increases the susceptibility of the installation to wind induced vibration and can impact on the visual environment in situations where significant amounts of downtilt are required.

In order to avoid the above difficulties, electrical beam steering can be effected by introducing phase delays into the signal input into radiating elements or groups of radiating elements in an antenna array. Such techniques are described in New Zealand Patent Specification No. 235010.

Various phase delay techniques are known, including inserting variable length delay lines into the network feeding to the radiating element or elements, or using PIN diodes to vary the phase of a signal transmitted through the feeder network.

A further means for varying the phase of two signals is described in PCT/NZ94/00107 whose disclosure is incorporated herein by reference. This specification describes a mechanically operated variable differential phase shifter incorporating one input and two outputs.

For the present purposes it is sufficient to note that phase shifters such as those described in PCT/NZ94/00107 are adjusted mechanically by sliding an external sleeve along the body of the phase shifter which alters the relative phase of the signals at the phase shifter outputs.

A typical panel antenna will incorporate one or more phase shifters and the present particular embodiment includes three phase shifters. A signal is input to the primary phase shifter which splits the signal into two signals having a desired phase relationship. Each phase shifted signal is then input into a secondary phase shifter whose outputs feeds at least one radiating element. In this manner a progressive phase shift can be achieved across the

entire radiating element array, thus providing a means for electrically adjusting the downtilt of the radiated beam. Other phase distributions are possible depending on the application and shape of the radiated beam.

While the steering action is discussed in the context of downtilt of the radiated beam, it is to be understood that the present detailed description is not limited to such a direction. Upward tilt may be produced as desired.

Another particular feature of the variable differential phase shifters is that they provide a continuous phase adjustment, in contrast with the more conventional stepped phase adjustments normally found in PIN diode or stepped length delay line phase shifters.

In a panel antenna of the type presently under consideration, it is desirable to adjust the entire phase shifter array simultaneously so that a desired degree of beam tilt may be set by the adjustment of a single mechanical setting means. The mechanical drive which performs such an adjustment must result in reproducible downtilt angles and be able to be adapted to provide for a number of different phase shifter array configurations.

It is an object of the present invention to provide a mechanical drive system for use in adjusting mechanical

phase shifters which mitigates the abovementioned difficulties, provides a solution to the design requirements of the antennas or antenna arrays described above, or at least provides the public with a useful choice.

Accordingly, there is provided a mechanical adjustment means for adjusting the relative phase shifts produced by a plurality of phase shifters connected to an array of radiating elements, said mechanical adjustment means including:

first means for moving a first portion of a first phase shifter relative to a second portion of said first phase shifter to vary the phase difference between output signals from the first phase shifter; and

second means for moving a first portion of a second phase shifter relative to a second portion of said second phase shifter to vary the phase difference between output signals from the second phase shifter, wherein the second phase shifter is fed from an output of the first phase shifter and the degree of movement of the second means is dependent upon the degree of movement of the first means.

Preferably, movement of the second means results in simultaneous movement of a first portion of a third phase shifter with respect to a second portion of the third phase

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shifter wherein the third phase shifter is fed from an output of the first phase shifter.

Preferably the outputs of the second and third phase shifters are connected to radiating elements so as to produce a beam which tilts as the first and second means adjusts the phase shifters.

Preferably the movement of the first portion of the first phase shifter relative to the second portion of the first phase shifter is twice the relative movement between first portions of the second and third phase shifters relative to second portions of the second and third phase shifters.

According to a first preferred embodiment the first means includes a gear wheel which drives a rack connected to a first portion of the first phase shifter, arranged so that rotation of the first gear wheel causes the first portion of the first phase shifter to move relative to the second portion of the first phase shifter. Preferably, the second portion of the first phase shifter is mounted to a carriage and the outputs of the first phase shifter are connected to inputs of the second and third phase shifters by push rods so that movement of the second portion of the first phase shifter moves the first portions of the second and third phase shifters with respect to the second portions of the second and third phase shifters.

Preferably a second gear is provided co-axial with and connected to a shaft driving the first gear which drives a rack connected to the second part of the first phase shifter so that rotation of the second gear causes movement of the first portion of the second and third phase shifters relative to the second portions of the second and third phase shifters.

Preferably the ratio between the first and second gear wheels is 3:1.

According to a second embodiment of the present invention the adjustment means includes a shaft and said first means includes a first threaded portion provided on said shaft and a first cooperating threaded member connected to the first portion of the first phase shifter. The second means includes a second threaded portion provided on said shaft and a second cooperating threaded member connected to the first portion of the second phase shifter. The arrangement is such that rotation of the shaft causes the first portion of the first phase shifter to move relative to the second portion of the first phase shifter at a rate twice that of the movement of the first portion of the second phase shifter relative to the second portion of the second phase shifter.

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Preferably the second threaded member is connected to the second portion of the first phase shifter and moves the first portion of the second phase shifter via a push rod. This push rod is preferably a coaxial line connecting an output from the first phase shifter to the input to the second phase shifter.

Preferably there is further provided a third phase shifter fed from a second output of the first phase shifter via a push rod which moves a first portion of the third phase shifter in unison with the first portion of the second phase shifter.

According to a further aspect of the invention there is provided an antenna system comprising one or more antenna including electromechanical means for varying the downtilt of the antenna and a controller, external to the antenna, for supplying drive signals to the electromechanical means for adjusting downtilt.

Preferably the system includes a plurality of antenna and the controller may adjust the downtilt for the plurality of antenna and store the degree of downtilt of each antenna in memory.

Preferably the controller may be controlled remotely from a control centre so that a plurality of such systems may be

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remotely controlled as part of a control strategy for a number of cellular base stations.

Preferably the electromechanical means varies the electrical downtilt of each antenna and means are included for monitoring the electromechanical means and providing signals representative of the position of the electromechanical means to the controller.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1: shows a panel antenna incorporating a phase shifter drive mechanism according to a first embodiment of the invention.

Figure 2: illustrates a primary phase shifter incorporating a gear rack.

Figure 3: illustrates an exploded view of the adjustment assembly incorporated into the carriage.

Figure 4: shows diagrammatically the operation of the drive mechanism according to the first embodiment.

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Figure 5: shows a panel antenna incorporating a phase shifter drive mechanism according to a second embodiment of the invention.

Figure 6: shows the phase shifter drive mechanism of figure 5 in detail..

Figure 7: shows the electrical connection of the motor, switches and reed switch of the drive mechanism shown in figure 6.

Figure 8: shows a controller for controlling the drive mechanism shown in figures 6 and 7.

Referring to figure 1 there is shown the back side of a panel antenna 4 having a first phase shifter 1, a second phase shifter 2, a third phase shifter 3 and a phase shifter drive mechanism 5. Feed line 6 is connected to input 7 of phase shifter 1. A first portion 8 of phase shifter 1 is moveable relative to a second portion 9 of phase shifter 1.

Output signals from phase shifter 1 are supplied via lines 10 and 11 to inputs 12 and 13 of phase shifters 2 and 3 respectively. Feed lines 10 and 11 comprise coaxial push rods which serve the functions both of feeding signals from the outputs of phase shifter 1 to phase shifters 2 and 3 and moving

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first portions 14 and 15 of phase shifters 2 and 3 relative to second portion 16 and 17 of phase shifters 2 and 3 respectively.

Signals output from phase shifters 2 and 3 are supplied via coaxial lines 18, 19, 20 and 21 to be fed to respective radiating elements (not shown).

In use first portion 8 of phase shifter 1 may be moved relative to second portion 9 of phase shifter 1 to change the relative phase of signals supplied via lines 10 and 11 to phase shifters 2 and 3 respectively. First portions 14 and 15 of phase shifters 2 and 3 may be moved relative to second portions 16 and 17 of phase shifters 2 and 3 to vary the phase of signals supplied by lines 18, 19, 20 and 21 to respective radiating elements.

When phase shifters 1, 2 and 3 are adjusted in the correct respective portions the beam emitted by the antenna can be tilted as required. It will be appreciated that where a less defined beam is required fewer phase shifters may be employed.

To achieve even continuous beam tilting for the embodiment shown in figure 1 the first portions 14 and 15 of phase shifters 2 and 3 should move relative to the second portion 16 and 17 of phase shifters 2 and 3 at the same rate. The first portion 8 of phase shifter 1 must however move relative to the second portion 9 of phase shifter 1 at twice this rate. In the arrangement shown

second portion 9 of phase shifter 1 is connected to carriage 22. Movement of carriage 22 results in movement of first portions 14 and 15 of phase shifters 2 and 3 via push rods 10 and 11.

Referring now to figure 4, operation of the phase shifter drive mechanism will be explained. Second portion 9 of phase shifter 1 is mounted to a carriage 22 which can move left and right. If carriage 22 is moved to the left first portions 14 and 15 of phase shifters 2 and 3 will be moved to the left via push rods 10 and 11. First portion 8 of phase shifter 1 may be moved relative to phase shifter 9 to vary the phase of signal supplied to phase shifters 2 and 3.

According to this first embodiment a rack 23 is secured to first portion 8 of phase shifter 1. Upon rotation of gear wheel 24 first portion 8 of phase shifter 1 may be moved to the left or the right. A smaller gear wheel 25 is secured to and rotates with gear wheel 24. This gear wheel engages with a rack 26 provided on carriage 22. A further gear wheel 27 is provided which may be driven to rotate gear wheels 24 and 25 simultaneously.

Gear wheel 24 has 90 teeth whereas gear wheel 25 has 30 teeth. It will therefore be appreciated that rotation of gear wheel 24 results in first portion 8 of phase shifter 1 being moved three times as far as carriage 22 (and hence first portions 14 and 15 of phase shifters 2 and 3). However, as carriage 22 is moving

in the same direction as the first portion 8 of phase shifter 1 it will be appreciated that the relative movement between first portion 8 and second portion 9 of phase shifter 1 is twice that of the relative movement between the first and second portions of phase shifters 2 and 3. Accordingly, this arrangement results in the relative phase shift produced by phase shifter 1 being twice that produced by phase shifters 2 and 3 (as required to produce even beam tilting in a branched feed arrangement).

The particular arrangement is shown in more detail in figures 2 to 4. It will be appreciated that gear wheel 27 may be driven by any appropriate manual or driven means. Gear wheel 27 may be adjusted by a knob, lever, stepper motor or other driven actuator. A keeper 28 may be secured in place to prevent movement once the desired settings of the phase shifters have been achieved.

Referring now to figures 5 and 6, a second embodiment will be described. As seen in figure 5, the arrangement is substantially the same as that shown in the first embodiment except for the drive mechanism employed, which is shown in figure 6.

In this embodiment the drive mechanism includes a shaft 31 having a first threaded portion 32 and a second threaded portion 33 provided thereon. A first threaded member 34 is connected to a first portion 35 of primary phase shifter 36. A second

threaded member 37 is connected to the second portion 38 of primary phase shifter 36.

First threaded portion 32 is of three times the pitch of second threaded portion 33 (e.g. the pitch of the first threaded portion 32 is 6mm whereas the pitch of the second threaded portion is 2mm). In this way, first portion 35 is driven in the direction of movement at three times that of second portion 38. In this way the phase shift produced by primary phase shifter 36 is twice that of second and third phase shifters 39 and 40.

Shaft 31 is rotated by motor 41. This may suitably be a geared down 12 volt DC motor. The other end of shaft 31 is supported by end bearing 42. A reed switch 43 is provided to detect when magnets 44 pass thereby. In this way the number of rotations of shaft 31 may be monitored. Limit switches 45 and 46 may be provided so that the motor is prevented from further driving shaft 31 in a given direction if threaded member 34 abuts a lever of limit switch 45 or 46 respectively.

Operation of the drive means according to the second embodiment will now be described by way of example. Motor 41 may rotate shaft 31 in an anticlockwise direction, viewed from right to left along shaft 3. Threaded member 37 is driven by second threaded portion 33 to move push rods 47 and 48 to the left, and thus to adjust phase shifters 39 and 40.

Threaded member 34 is driven to the left at three times the rate of threaded member 37. First portion 35 thus moves to the left at three times the rate of second portion 38. First portion 35 therefore moves relative to second portion 38 at twice the speed the first portions of phase shifters 39 and 40 move relative to their respective second portions. In this way, delays are introduced in the paths to respective radiating elements so as to produce an evenly tilting beam.

The conductivity of reed switch 43 is monitored so that the number of rotations, or part rotations, of shaft 31 may be monitored. If the motor continues driving shaft 31 until threaded member abuts the lever of limit switch 45 then logic circuitry will only permit motor 41 to drive in the opposite direction. Likewise if threaded member 34 abuts the lever of limit switch 46 the motor 41 will only be permitted to drive in the opposite direction.

It will be appreciated that the techniques of both embodiments could be employed in antenna arrays using a larger number of phase shifters. In such applications the relative movement of the first portion of each phase shifter relative to the second portion of each phase shifter would be decreased by a factor of 2 for each successive phase shifter along each branch. The ratios used may be varied if the radiation pattern of the antenna needs to be altered to account for the directivity of the individual radiating elements and the effect of the back panel as the amount of downtilt is varied.

Components of the drive mechanism are preferably formed of plastics, where possible, to reduce intermodulation. Threaded members 34 and 37 preferably include plastic links to phase shifter 36 to reduce intermodulation.

It will be appreciated that a number of mechanical drive arrangements may be used to achieve adjustment of the phase shifters in the desired ratio. It is also to be appreciated that sophisticated control electronics may be employed, although the simplicity of construction of the present invention is seen as an advantage.

Figure 7 shows how motor 41, reed switch 43 and switches 45 and 46 are connected to lines 71, 72, 76 and 77 from an external controller. Lines 71 and 72 supply current to drive motor 41. Section 73 ensures that if threaded member 34 is driven to either the left-hand side limit or the right-hand side limit it can only be driven in the opposite direction. In the position shown in figure 7, switch 45 directly connects line 71 to switch 46 via diode 74. In the position shown switch 46 connects line 71 to motor 41 via diode 75. This is the normal position of the switches when threaded member 34 is not at either extreme limit. When threaded member 34 is driven to the extreme left, for example, and actuates switch 45, then switch 45 open circuits the path via diode 74. Diode 74 allows current flow in the direction allowing motor 41 to drive to the left. Accordingly, when switch 45 is open, motor 41 can only drive in such a direction as to drive threaded member 34 to the right (i.e.: current in the direction allowed by diode 75).

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Likewise, if threaded member 34 is driven to the extreme right, switch 46 is opened to break the path via diode 75. This prevents motor 41 driving in such a direction as to drive threaded member 34 further to the right.

Lines 76 and 77 are connected to reed switch 43 so that the opening and closing of reed switch 43 may be monitored by an external control unit. In use, the opening and closing of reed switch 43 may be monitored to determine the position of threaded member 34, and hence the corresponding degree of tilt of the antenna.

To select an initial angle of downtilt threaded member 34 may be driven to the extreme right. An external controller may provide a current in one direction to motor 41 to drive member 34 to the right. The motor will continue to be driven to the right until threaded portion 34 abuts switch 46. When switch 46 is opened diode 75 will be open circuited, which will prevent the motor being driven further to the right.

The controller will sense that threaded member 34 is at its extreme right position as it will detect that reed switch 43 is not opening and closing. After a predetermined delay the controller may then provide a current in the opposite direction via lines 71 and 72 to motor 41 to drive it to the left. As the motor is driven to the left the controller will monitor the

opening and closing of reed switch 43 to determine how far threaded member 34 has moved to the left. The controller will continue to move threaded member 34 to the left until reed switch 43 has opened and closed a predetermined number of times, corresponding to a desired angle of downtilt. Alternatively, member 34 may be driven to the extreme left and then back to the right.

At an antenna site a number of such panels may be installed and controlled by a single controller 80 as shown in figure 8. The four wires 71, 72, 76 and 77 correspond to respective cable groups 78 to three such antenna panels. Controller 80 may be provided at the base of an antenna site to allow an operator to adjust the tilt of a plurality of antennas at ground level, rather than requiring a serviceman to climb up the antenna structure and adjust each antenna manually.

Controller 80 may include a display 81, an "escape" button 82, an "enter" button 83, an "up" button 84 and a "down" button 85. At power up display 81 may simply display a home menu such as "Deltec NZ Ltd © 1995". Upon pressing any key, a base menu may be displayed including options such as:

- unlock controls
- set array tilt
- measure tilt

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enable array
disable array
lock controls

The up/down keys may be used to move through the menu and the enter key 83 used to select an option. If "unlock controls" is selected a user will then be required to enter a three digit code. The up/down keys may be used to move through the numbers 0 to 9 and enter used to select each number. If the correct code is entered "locked released" appears. If the incorrect code is entered "controls locked" appears and a user is returned to the home menu.

If "set array tilt" is selected from the base menu the following may appear:

set array tilt
array:01 X.X°

The up-down keys 84, 85 may be used to select the desired array number. The enter key accepts the selected array and the previously recorded angle of downtilt may be displayed as follows:

set array tilt
array: 01 4.6°

In this example the previously set angle of downtilt with 4.6°. Using the up/down keys 84,85 a new angle may be entered.

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Controller 80 may then provide a current to motor 41 via lines 71 and 72 to drive threaded portion 34 in the desired direction to alter the downtilt. The opening and closing of reed switch 43 is monitored so that threaded member 34 is moved in the desired direction for a predetermined number of pulses from reed switch 43. The downtilt for any other array may be changed in the same manner. If the controller is locked a user may view an angle of downtilt but will not be able to alter the angle.

If the "measure array" option is selected the present angle of downtilt of the antenna may be determined. Upon selecting the "measure tilt" function from the base menu, the following display appears:

```
measure tilt
array: 01 X.X°
```

The up/down buttons may be used to select the desired array. The enter key will accept the selected array. To measure the actual angle of downtilt controller 80 drives a motor 41 of an array to drive member 34 to the right. Motor 41 is driven until threaded member 34 abuts switch 46. The controller counts the number of pulses from reed switch 43 to determine how far threaded portion 34 has travelled. At the extreme right position the controller determines and displays the angle of downtilt, calculated in accordance with the number of pulses connected from reed switch 43. The controller then drives threaded member 34 back in the opposite direction for the same

number of pulses from reed switch 43 so that it returns to the same position. The angle of downtilt for each antenna may be stored in memory of controller 80. This value will be updated whenever the actual angle of downtilt is measured in this way. The "measure tilt" function may not be used if the controller is locked.

Controller 80 may include tables in memory containing the number of pulses from reed switch 43 that must be counted for threaded member 34 to achieve each desired degree of downtilt. This may be stored as a table containing the number of pulses for each required degree of downtilt, which may be in $.1^\circ$ steps. This approach ensures that any non-linearities of the antenna may be compensated for as the tables will give the actual amount of movement required to achieve a desired downtilt for a given antenna.

The "enable array" function may be used to enable each array when installed. The controller will be prevented from moving any array that has not been enabled. Controller 80 will record in memory which arrays have been enabled. The "disable array" function may be used to disable arrays in a similar manner.

The "lock controls" function may be used to lock the controller once adjustment has been made. A "rack error" signal may be displayed if the array has not operated correctly. This will indicate that an operator should inspect the array.

Adjustment of the array may also be performed remotely. Controller 80 may be connected to modem 86 via serial line 87 which may connect via telephone line 88 to a central controller 89. The functions previously discussed may be effected remotely at central controller 89. In a computer controlled system adjustments may be made by a computer without operator intervention. In this way, the system can be integrated as part of a control strategy for a cellular base station. For example, a remote control centre 89 may adjust the downtilt of antennas at a cellular base station remotely to adjust the size of the cell in response to traffic demand. It will be appreciated that the capability to continuously and remotely control the electrical downtilt of a number of antenna of a cellular base station may be utilised in a number of control strategies.

Controller 80 may be a fixed controller installed in the base of an antenna site or could be a portable control unit which is plugged into connectors from control lines 78.

Where in the foregoing description reference has been made to integers or components having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example it is to be appreciated that improvements and/or modifications may

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be made thereto without departing from the scope or spirit of
the present invention.

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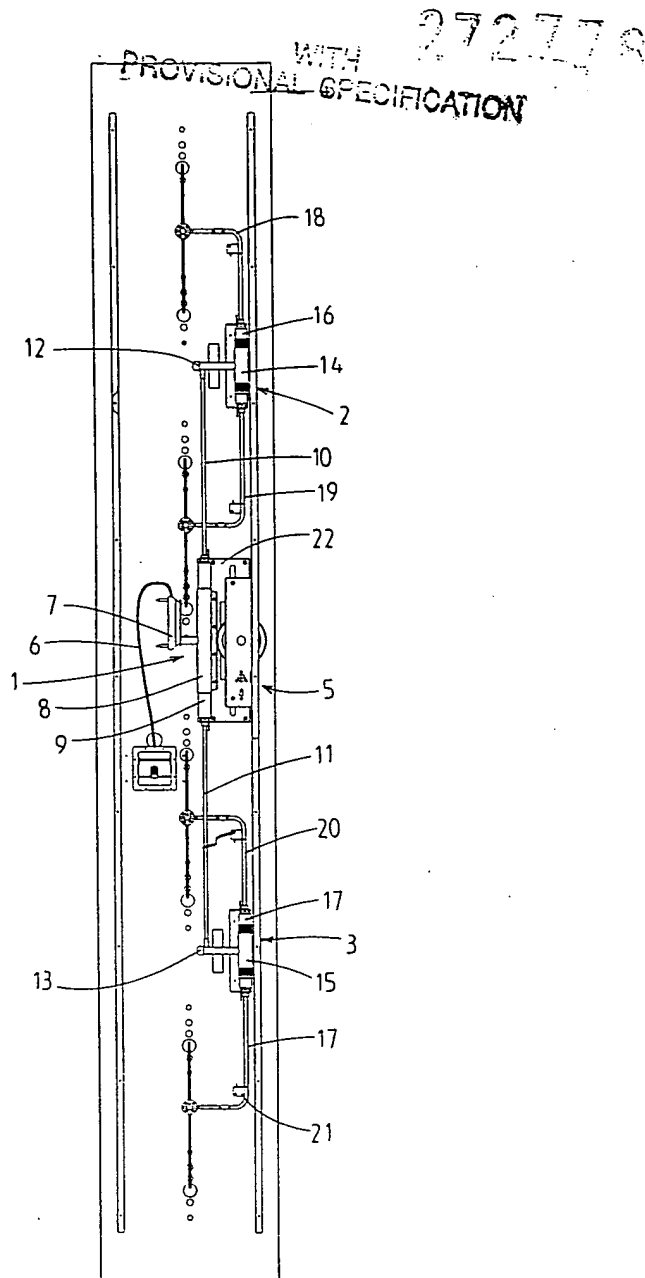
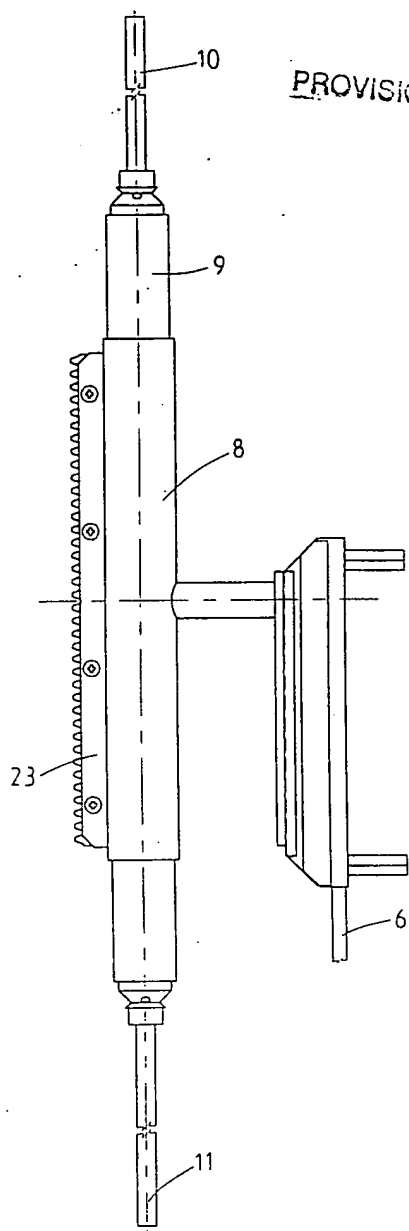


FIG.1

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FIG. 2

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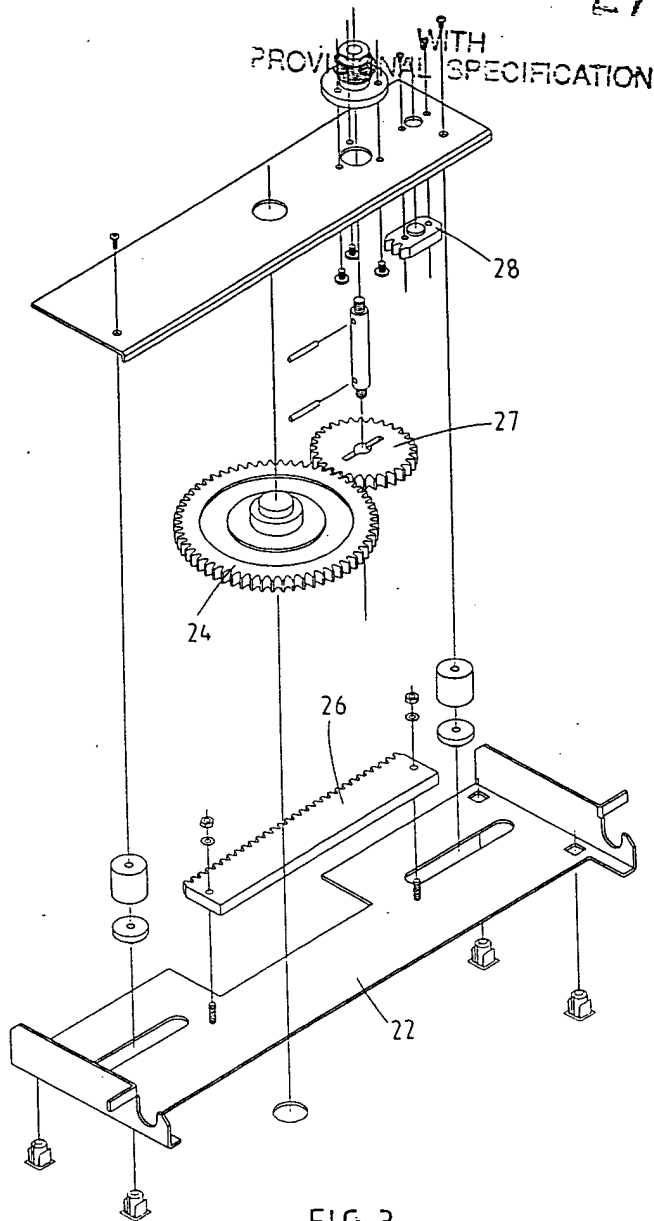


FIG. 3

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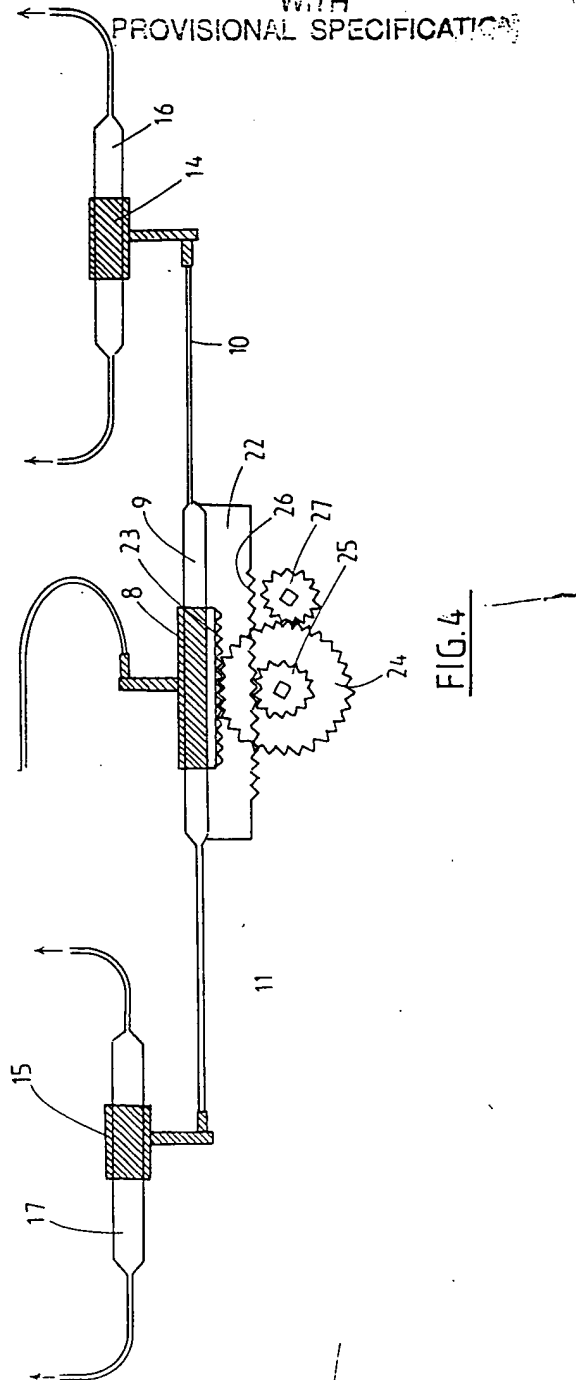


FIG. 4

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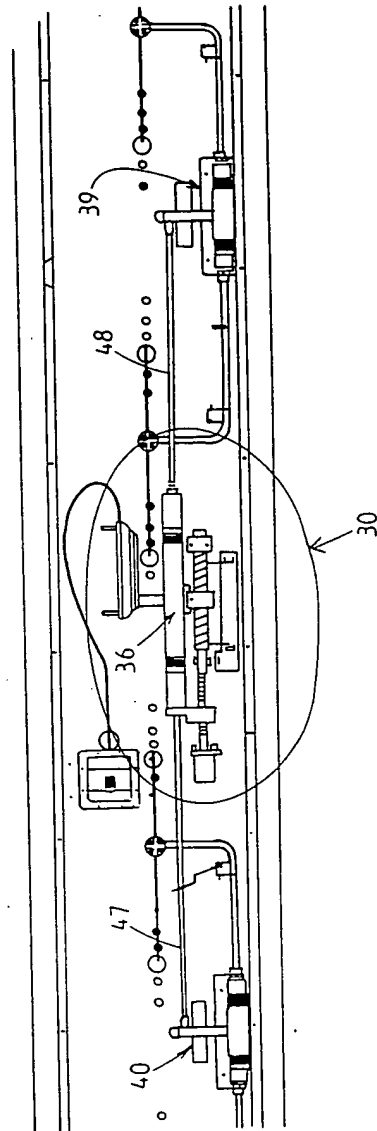


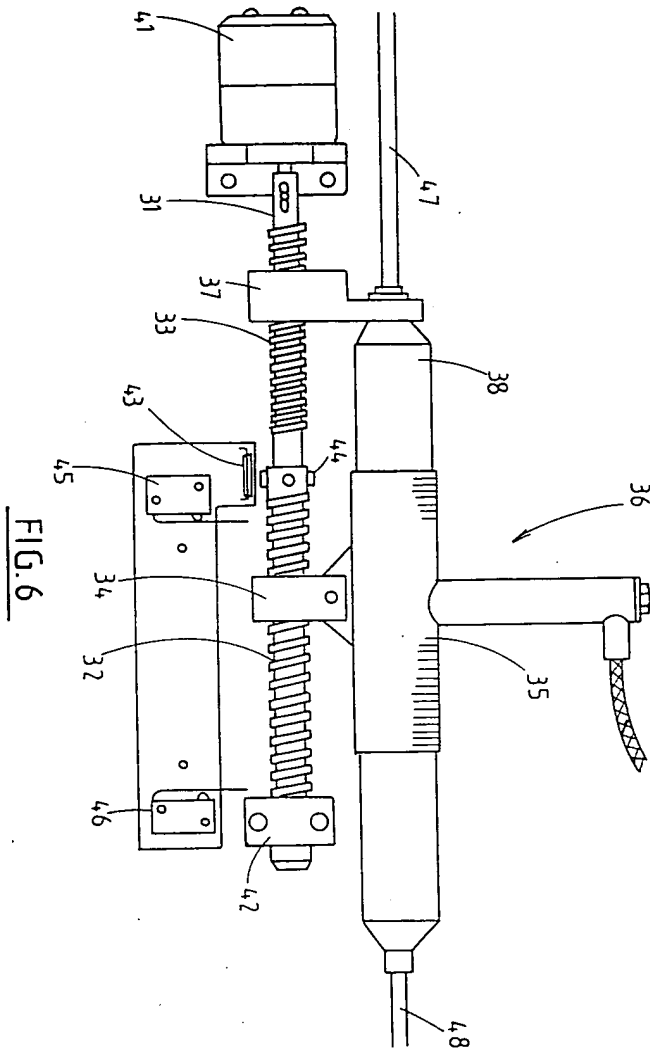
FIG. 5

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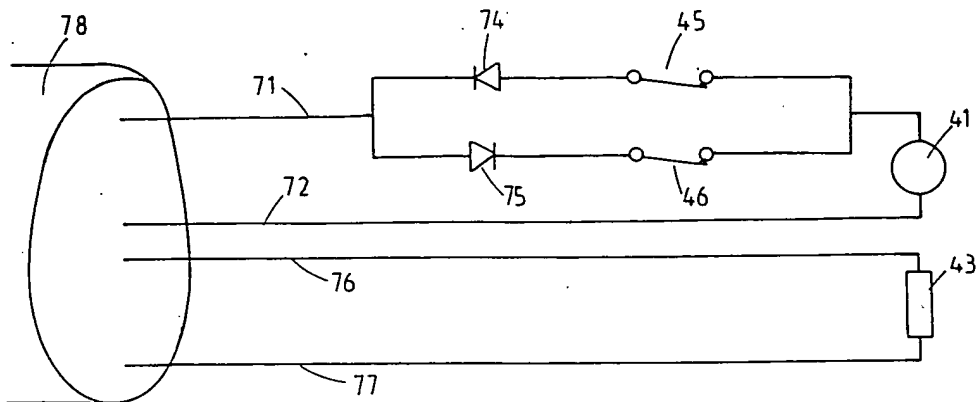


FIG. 7

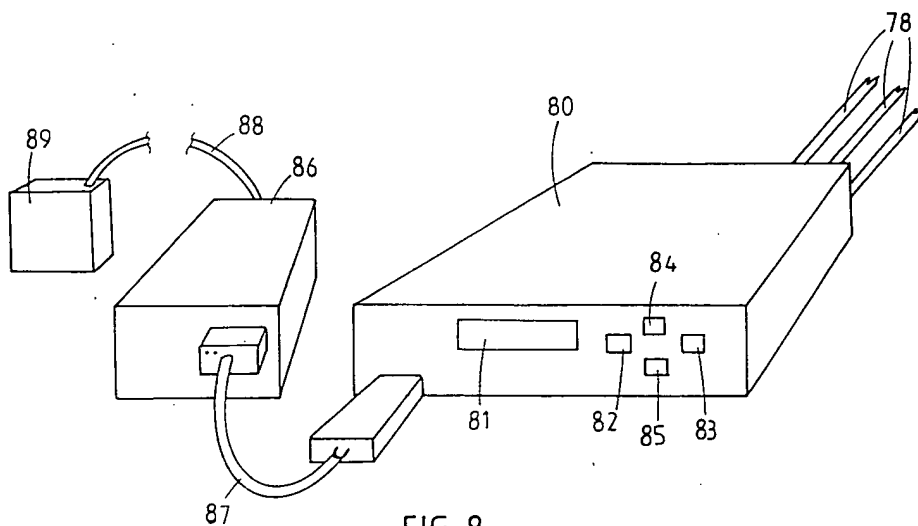


FIG. 8

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